Fragmentation functions for pions, kaons, protons and charged hadrons

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Abstract. We present new sets of pion, kaon, proton and inclusive charged hadron fragmentation functions obtained in NLO combined analyses of single-inclusive hadron production in electron-positron annihilation, proton-proton collisions, and deep-inelastic lepton-proton scattering with either particles identified in the final state. At variance with all previous fits, the present analyses take into account data where hadrons of different electrical charge are identified, which allow to discriminate quark from anti-quark fragmentation functions.

1. Introduction

In the last few years there has a growing interest in accurate parameterizations for fragmentation functions driven by the increasing role of one particle inclusive measurements as tools able to provide valuable information on many subjects, including the spin and flavor structure of the nucleon, nuclear modifications of parton densities and fragmentation functions, and in general, as a window to the non-perturbative regime, much more incisive than totally inclusive measurements.

In this context, parametrizations for fragmentation functions have been extracted, however, mostly based on single inclusive electron-positron annihilation measurements. These data give per se no information on how to disentangle quark from anti-quark fragmentation, and fixes mainly the flavor singlet combinations of fragmentation functions at intermediate hadron energy fractions. The gluon fragmentation is also not exceedingly well constrained, since its contribution enter as a higher order correction, and the scale dependence is too weak to determine it.

In the following we very briefly summarize results from a global analysis where we have determined individual fragmentation functions for quark and anti-quarks for all flavors, as well as gluons, from a much larger set of data [1, 2]. The addition of semi-inclusive deep inelastic scattering (SIDIS) and proton-proton collisions measurements not only increases statistics, but have the advantages of charge discriminated final states, different ranges for the scale and energy fractions, and different sensitivity to the partonic species.

2. Parameterizations and results

In order to have the flexibility required by charge separated distributions and to accommodate the additional data, we adopt a somewhat more versatile functional form for the input

distributions than in previous extractions of fragmentation functions [3, 4, 5, 6]

$$D_i^H(z,\mu_0) = N_i z^{\alpha_i}(1-z)^{\beta_i}[1+\gamma_i(1-z)^{\delta_i}], \tag{1}$$

where the initial scale μ_0 in Eq. (1) is taken to be $\mu_0 = 1\,\mathrm{GeV}$ for the lighter partons and the quark masses for the heavier ones. To reduce the number of parameters to those that can be effectively constrained by the data, we are forced to make some plausible assumptions; for example we impose isospin symmetry for the sea fragmentation functions in the case of pions, i.e. $D_{\bar{u}}^{\pi^+} = D_{d}^{\pi^+}$, but we allow for slightly different normalizations in the $q+\bar{q}$ sum: $D_{d+\bar{d}}^{\pi^+} = N D_{u+\bar{u}}^{\pi^+}$. For strange quarks it is assumed that $D_s^{\pi^+} = D_{\bar{s}}^{\pi^+} = N' D_{\bar{u}}^{\pi^+}$. Similar assumptions are made in the case of kaons, protons, and the remaining charged hadrons. For further details see [1, 2].

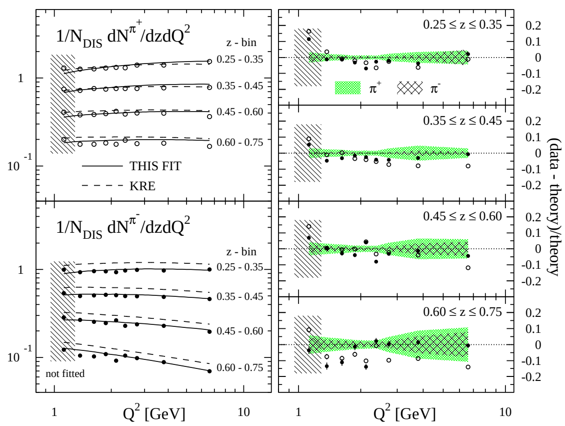

Figure 1. Comparison with HERMES pion SIDIS data [7]. The label KRE denotes estimates with the set of reference [4]

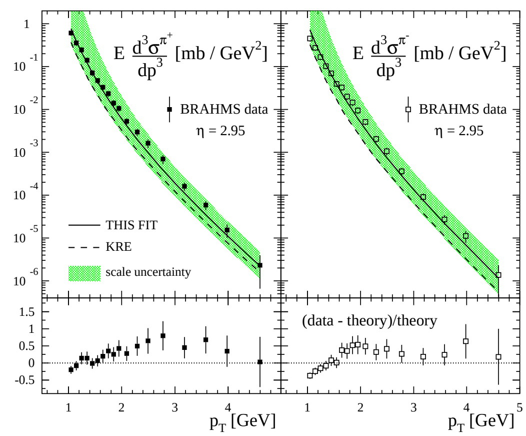

Figure 2. Comparison with BRAHMS pion production data in pp collisions [7].

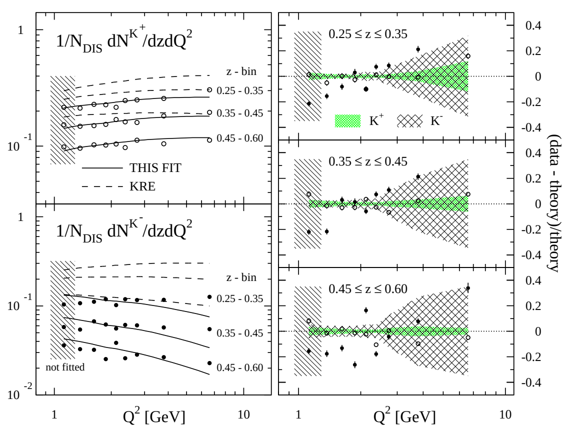

Figure 3. The same as Fig.1 but for kaons.

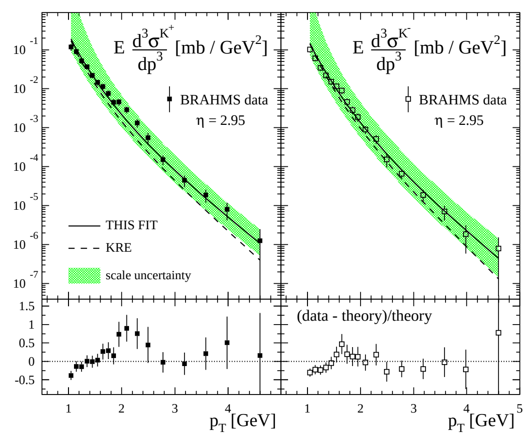

Figure 4. The same as Fig.2 but for kaons.

As a common feature of all the fits, we find that our new sets of fragmentation functions are hardly to distinguish from the previous ones when compared to electron positron annihilation

data, but as expected, the differences become apparent when they are compared to data that imply charge separation (Figs. 1-4), specially in the case of kaons (Figs. 3, 4), and for observables sensitive to the gluon fragmentation and large hadron energy fractions (Fig. 5). Proton as well

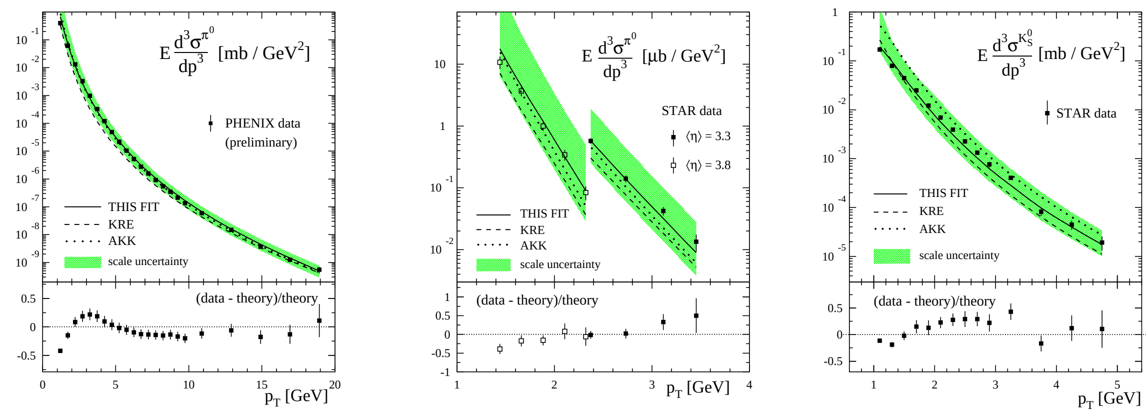

Figure 5. Comparison with PHENIX and STAR neutral pion and kaon production data in pp collisions [7]. The label KRE and AKK denotes estimates with the sets in [4] and [5] respectively.

as inclusive charged hadron production data are well reproduced (Figs. 6, 7). Fortran routines providing LO and NLO fragmentation functions are available upon request from the authors.

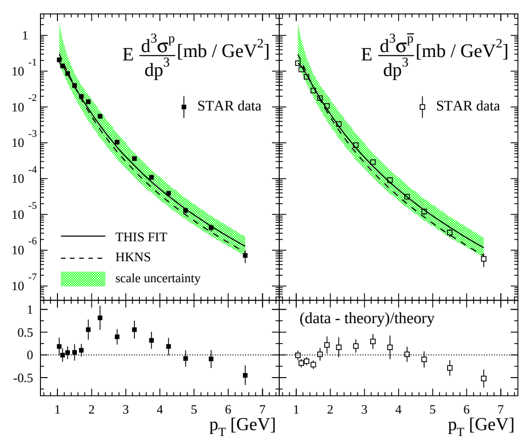

Figure 6. Comparison with STAR data on (anti)proton production [7] and the set in [6].

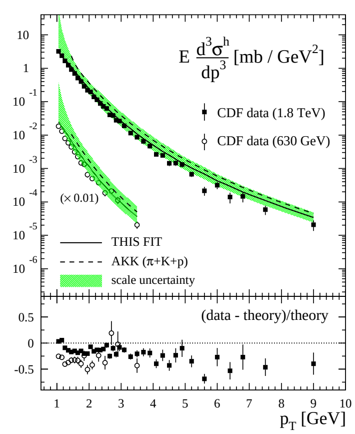

Figure 7. Comparison with CDF inclusive charged hadron production data [7]

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[7] For a detailed account of the data sets included in the fit see [1] and [2].